

# The role of thought experiments in learning special relativity in secondary education

There is a growing international interest in implementing special relativity theory (SRT) into pre-university education as a first introduction to modern physics. Currently, studies on learning opportunities and challenges are sparse, especially at the level of secondary education, and there is a need for a general overview and synthesis of the results reported.

We aim to contribute to the international collaboration of physicists education researchers by presenting a literature review on SRT education at the secondary and lower undergraduate level. For this review, we have selected and analysed 39 articles and categorized them according to reported learning difficulties, teaching approaches and research tools. Analysis shows that students at all educational levels experience robust learning difficulties with the use of frames of reference, the postulates of SRT and relativistic effects. Some teaching approaches approach this problem by focusing on thought experiments to express conceptual features of SRT, while others use virtual environments to provide realistic visualisation of relativistic effects. Finally, we show that students' conceptual understanding of SRT is primarily measured by means of thought experiments, which we group into five categories related to basic concepts from Galilean relativity and SRT.

Our review indicates that careful construction and evaluation of thought experiments plays a pivotal role in the process of learning SRT. In our next study, we aim to investigate how this process can be supported by means a novel computer modeling and simulation tool. In the proposed modeling tool, students can construct thought experiments by placing virtual objects, light sources and clocks onto a two-dimensional grid, and assign relative velocities. By switching between inertial frames of reference associated with the objects, students are able to explore the behavior of light rays and relatively moving clocks. We share our design principles and present our first prototypes.